

TITLE

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Lighter and heavier initial loads yield similar gains in strength when employing a progressive wave loading scheme

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ABSTRACT: Progressive wave loading strategies are common within strength and conditioning practice. The purpose of this study was to contribute to the understanding of this strategy by evaluating the effectiveness of 2 wave loading bench press training programmes that differed only in the initial load that was used to start the first wave. Thirty-four resistance-trained men were divided into 2 groups and performed 2 training sessions each week for 20 weeks. One session consisted of 6 sets of 2 repetitions, while the other consisted of 5 sets of 5 repetitions. The load used was incremented by 2.5% of one repetition maximum (1RM) each week until the subject could no longer complete the programmed repetitions. At this point, the load was decreased, and then started to ascend again. The initial loads for the 2 sessions were 87.5% and 80% 1RM respectively for the heavier group, and for the lighter group were 82.5% and 75% 1RM. The subjects experienced a significant improvement in their bench press performance (higher load group: pre test = 106.5 kg \pm 14.6, post test = 112.2 kg \pm 12.4, $p \leq 0.05$; lower load group: pre test = 105.7 kg \pm 14.1, post test = 114.3 kg \pm 11.0, $p \leq 0.05$), but there was no difference in the magnitude of the improvement between the two groups. These results tend to support the common practical recommendation to start with a lighter load when employing a progressive wave loading strategy, as such a strategy yields similar improvements in performance with a lower level of exertion in training.

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INTRODUCTION

It is generally accepted that the systematic variation of training stimuli (periodization) is effective in optimizing the response to resistance training [1–3]. For this reason, there has been a considerable amount of interest in comparing different periodization strategies in order to evaluate their relative effectiveness. For instance, in a recent systematic review Harries and colleagues [4] found 17 studies that compared linear to undulating periodization programmes that met their inclusion criteria. Despite this volume of research, the most effective periodization strategies have yet to be determined.

One potential reason for the lack of definitive training recommendations for periodization strategies is the nature of previous experimental designs. For instance, if trying to contrast the effectiveness of 2 different periodization schemes (e.g. linear and undulating periodization) it is likely that the programmes will differ on a number of key variables, even when using simple programmes and when an effort is made to equate variables like volume load [e.g. 5,6–8]. There is thus a need for training studies that strictly manipulate only one precisely defined variable, and that can give more definitive answers to specific research questions.

Progressive loading of intensity is a common periodization strategy whereby the relative load lifted is gradually increased over the course of a training cycle [1,9,10]. This strategy is sometimes called “wave” loading if, once the athlete reaches the end of a cycle (indicated by them not being able to complete the programmed repetitions), they then reduce the loading and start progressively increasing the intensity again. For those employing such a strategy, a common recommendation within the training literature is to start the training cycle with a very conservative load [i.e. a relatively light load; 11,12,13]. This is based upon the observation that many athletes will initially tend to select a load which requires them to work quite hard [11]. In this case, unless the athlete shows dramatic increases in strength in a very short time period, they will quickly get to a point where they can't complete the programmed session, resulting in a short training cycle. The advantage of starting with a lighter load is that the training cycle will be longer in duration (although it is important that the initial stimulus is sufficient to induce training adaptations). However, the effectiveness of this recommendation has not been tested within the literature.

The purpose of this study was therefore to evaluate the effect of the initial load used in a wave loading progressive resistance training programme. The focus on manipulating just one, narrowly defined variable, was considered to be attractive given the possibility of being able to provide a more definitive training recommendation. In particular, the purpose of this study was to test the null hypothesis that there would be no significant difference in the bench press strength gains seen in experienced lifters following wave loading training programmes of differing initial intensities.

MATERIALS AND METHODS

Experimental Approach to the Problem. This pre test/post test experimental study involved 2 groups of resistance trained men following similar bench press training programmes for 20 weeks. The loading in each programme was progressed in a wave-like fashion, with the 2 programmes differing in terms of the initial load that was prescribed. The hypotheses were tested by a comparison of the improvement in bench press performance between the 2 groups.

Subjects

Thirty four strength trained males with at least 2 years of experience in performing the bench press exercise volunteered to take part in this study. Subjects were randomly assigned to 2 groups that differed in terms of the relative load of the initial load prescription (that is a lighter (L) or heavier (H) initial load). There were no significant differences in the body mass, or in the absolute or relative strength of the 2 groups (Table 1). The H group was significantly taller and older than the L group ($p \leq 0.05$), however the magnitude of these differences was small. All of the subjects were informed of the purpose and potential risks of the investigation and provided written informed consent. The study was approved by the institutional review board of St Mary's University, Twickenham.

Procedures

Prior to commencing the training intervention, all subjects attended 2 supervised familiarization sessions to receive instruction on bench press form, and the details of the programme they would be following. Their 1RM bench press performance was also assessed during

these sessions using standard procedures [14] following a standardized warm up. The subjects then completed the 20 week training programme, providing subjective reports on their progress to the first author by email (however, the actual training completed by the subjects was not formally tracked). Finally, subjects attended a further supervised session at the end of the training programme at which point their 1RM was reassessed.

Training Programme

The bench press training programme consisted of 2 training sessions per week (separated by at least 48 hours) for 20 weeks. In the first session each week the subjects performed 6 sets of 2 repetitions with the prescribed load, whereas in the second session subjects performed 5 sets of 5 repetitions. The prescribed load for each session was increased by 2.5% of 1RM each week following a wave-like progression. The loading was increased each week until the subject could not complete the session. For the first session, failure to complete the session was adjudged to have occurred if the subject could not complete 2 repetitions for at least 4 of the 6 sets. For the second session, failure to complete the session was adjudged to occur if the subject could not complete at least 4 repetitions of the last set. Following failure to complete a session, the loading in the subsequent week was reduced and a new wave of loading commenced. The new wave started with a load that was 2.5% of 1RM greater than the load that was used to start the preceding wave.

The 2 groups differed in terms of the load that was used to start the initial waves. The H group used initial loads of 87.5% and 80% of 1RM for sessions 1 and 2 respectively, whereas the L group used initial loads of 82.5% and 75% of 1RM for sessions 1 and 2. These loads were chosen in the following way (using session 1 as an example). Firstly, we assumed that the 2 repetition maximum of the subjects would be around 95% of 1RM [14] – this then represented the maximum possible intensity for a session of 6 sets of 2 repetitions (based on the pre-test strength scores). We then chose the starting loads such that the H group would be training at this intensity after 4 weeks and the L group would be training at this intensity after 6 weeks. These durations were considered appropriate as they are consistent with the length of commonly programmed training

TABLE 1. Subject characteristics presented as mean \pm standard deviation.

	Heavier Initial Load	Lighter Initial Load
Age (years)	31.1 \pm 3.5	28.9 \pm 2.4*
Body Mass (kg)	88.0 \pm 5.2	87.4 \pm 6.8
Height (m)	1.81 \pm 0.02	1.79 \pm 2.2*
1RM Bench Press (kg)	106.5 \pm 14.6	105.7 \pm 14.1
1RM Bench Press/Body Mass ^{2/3} (kg ^{1/3})	5.4 \pm 0.6	5.4 \pm 0.5

Note: * = significant difference between groups; $p \leq 0.05$

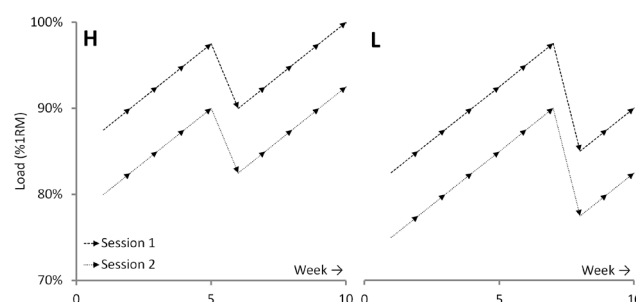


FIG. 1. An illustration of a potential intensity progression for a hypothetical subject from each group.

Note: H = heavier initial load; L = lighter initial load.

phases [15], while at the same time giving a considerable contrast in the length of the training phase. Finally, we also predicted that the session of 95% of 1RM would be the last complete session in the first cycle (assuming a strength gain of 2.5% of 1RM in the first cycle the new 2 repetition maximum would be around 97.5% of 1RM, and thus it would be unlikely that the subjects could complete 6 sets at this intensity). Figure 1 illustrates a comparison of a potential wave progression for a hypothetical subject from each group.

Aside from the programme described above, subjects were granted the autonomy to decide on the content of any additional training. This decision was taken to improve the adherence of the subjects to the programme, given the length of its duration and the fact that subjects were accustomed to directing their own training.

Statistical Analysis

Statistical analysis was performed using SPSS (version 21, IBM) and Microsoft Excel. Pre test comparisons of subject characteristics were performed using 2 tailed independent t-tests. Bench press performance was scaled relative to body weight by dividing it by body weight raised to the $\frac{2}{3}$ power [14,16]. Each training group was then divided into a stronger or weaker group (scaled bench press performance greater or lesser than the mean). A repeated measures ANOVA was then used to test for differences in bench press improvement where the within subjects factor was time (pre and post test scores) and the between subjects factors were training group (H or L) and strength group (stronger or weaker). Effect sizes were quantified by the calculation of partial η^2 . An alpha level of $p < 0.05$ was set a priori for all tests.

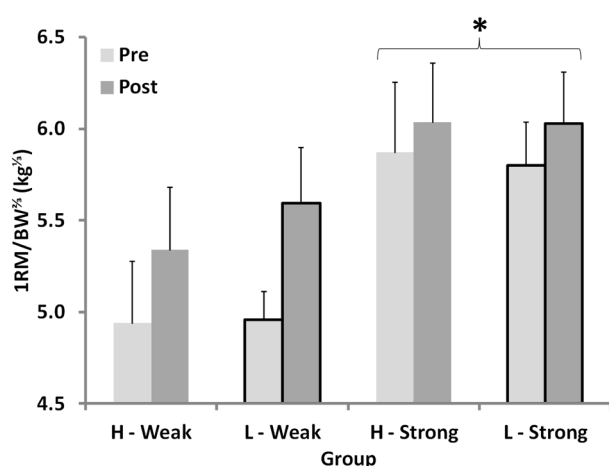


FIG. 2. Change in body weight adjusted bench press performance (mean \pm standard deviation) after a 20 week training programme. Note: Results are presented for the 4 sub groups considered: H and L indicate those subjects who trained on the programmes with heavier and lighter initial loads respectively; strong and weak indicate stronger and weaker subjects based upon initial bench press performance. * = significant difference between the response of the strong and weak subjects ($p \leq 0.05$).

RESULTS

No lapses in programme adherence (or any other problems) were reported by the subjects during the 20 week programme. There was a statistically significant main effect of time indicating an increase in bench press performance from pre to post test ($F(1,30) = 82.82$, $p < 0.001$, $\eta^2 = 0.734$; H: pre test = $106.5 \text{ kg} \pm 14.6$, post test = $112.2 \text{ kg} \pm 12.4$; L: pre test = $105.7 \text{ kg} \pm 14.1$, post test = $114.3 \text{ kg} \pm 11.0$). The weaker subjects experienced a greater increase in strength than the stronger subjects over the course of the study (a statistically significant time \times strength group interaction effect; $F(1,30) = 17.09$, $p < 0.001$, $\eta^2 = 0.363$; Figure 2). There was no significant interaction effect for the time \times training group interaction ($F(1,30) = 3.59$, $p = 0.068$, $\eta^2 = 0.107$), or the time \times training group \times strength group interaction ($F(1,30) = 1.15$, $p = 0.292$, $\eta^2 = 0.037$).

DISCUSSION

In this study, the subjects experienced a significant increase in bench press strength ($5.7\% \pm 3.7$ and $8.7\% \pm 7.0$ for the H and L groups respectively), although there was no significant difference in the magnitude of the gain between the two groups. These results suggest that when performing a wave loading protocol of the type used in this study that starting with a lighter initial load will result in a similar performance improvement as starting with a heavier load. It can therefore be suggested that starting with a lighter initial load is advantageous as the same performance improvement can be gained with the exertion of less effort (i.e. by training at a lower intensity). It should also be noted that the difference in the improvement between the groups approached significance ($p = 0.068$), with the L group showing the greater improvement. Future research should seek to employ research designs with increased power to evaluate whether starting with a lighter initial load can actually deliver greater gains.

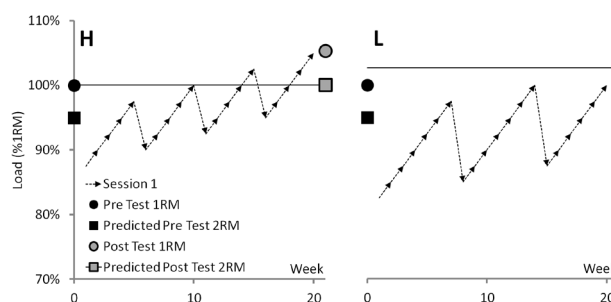


FIG. 3. A comparison of the idealized loading cycles for the subjects in this study to the actual strength gains that they experienced (the assumptions upon which this figure is based are described within the text).

One explanation for the results seen in this study can be derived from a consideration of the magnitude of adaptation realized by the 2 groups and the time course of the loading progression (Figure 3). In Figure 3, it is assumed that the final load for session 1 (6 sets of 2 repetitions) was 97.5% of 1RM for each group. It is then assumed that in each subsequent cycle the subjects are able to finish 2.5% of 1RM higher than the previous cycle. The horizontal lines on Figure 3 represent the predicted 2RM of the subjects at the end of the training programme. It is clear that for the subjects in group L that throughout the programme they would be training with a load that is less than their final 2RM in session 1. However, based upon these assumptions, the subjects in group H would be required to train with a load above their final 2RM for a number of sessions – this is clearly not possible as the session involves the performance of multiple sets of 2 repetitions.

Thus it is clear that the rate of improvement for subjects in group H cannot be modeled by the assumptions utilized in Figure 3. Given the parameters of the programme in this study, the length of the cycles experienced by group H must have been shorter – for instance as indicated in Figure 4. A consequence of this is that group H would spend much more time training with loads that are close to maximal than is the case for group L. Thus, the average intensity employed by group H would be higher, and the programme less differentiated. This difference in the difficulty of the programme is certainly consistent with the subjective reports received from the subjects. Therefore in this study, training at higher intensity did not provide any additional benefit when compared to training at a lower intensity. The results reported in this study may therefore be consistent with the growing body of evidence indicating that prolonged periods of resistance training at high intensities may diminish performance [17–19].

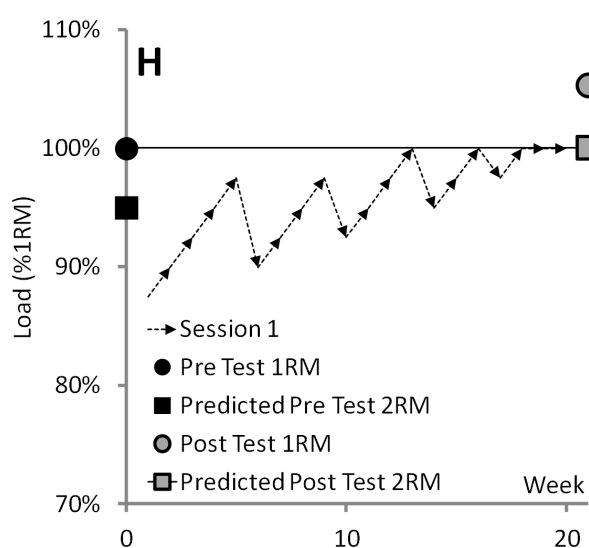


FIG. 4. A potential sequence of loading cycles for the subjects in the heavier group that matches the strength gains observed.

In the programme followed here, it seems likely that group H followed a more intense programme as the rate of progression of loading was greater than the rate at which strength was increased (as illustrated in Figure 3). In contrast, it appears that the rate of loading progression for group L was matched much more closely to the rate of strength increases. In this study, the rate at which loading was increased was the same for both groups. This in turn meant that, provided the rate of strength increase was not markedly greater for group H, that the length of the cycles for group H would be shorter. An outstanding question is therefore what the effect would be if the size of the loading increments was decreased in order to account for the higher initial load. For instance, Figure 5 shows that if the load used by group H was only increased by 1.7% of 1RM each week then the loading profile would be much more similar to that of group L (based on the same assumptions used in Figure 3). Future research should therefore seek to compare loading profiles similar to those in Figure 5, to ascertain whether a lighter initial load results in the same gains in strength as a heavier initial load when the cycle lengths are more evenly matched (and also when cycle lengths are matched to the rate of adaptation).

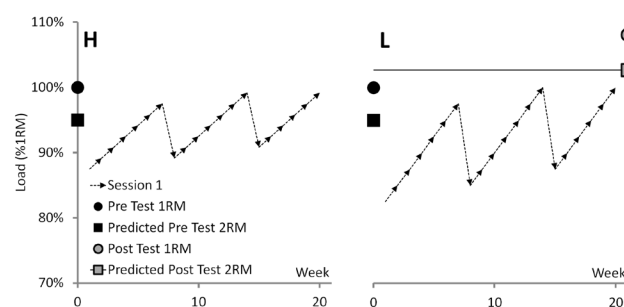


FIG. 5. A potential sequence of loading cycles that might result in loading cycles of more even length between the lighter and heavier groups and that could be investigated in future research (the assumptions upon which this figure is based are described in the text).

A clear limitation of this study is the lack of monitoring of the response of the subjects to the training protocol, in terms of the sets and repetitions completed and the load used. This means that it is not possible to give a definitive and quantitative description of the lengths of the cycles and the loads used (and it should be emphasized that Figures 3–5 represent idealized potential situations, not the actual loading experienced by the subjects in this study). However, given that the parameters of the progression are known, as are the final performance improvements, this information can be sensibly estimated (as provided above). Equally, the adherence of the subjects to the programme was not formally tracked, although based upon the subjective reports of the subjects provided by email there is no reason to doubt that the programme was not completed as man-

dated. In any case, these limitations do not change the overall recommendations that emerge from this study, because even the most conservative interpretation of these results suggests that simply giving the instruction to start with a lighter initial load is as effective as giving the instruction to start with a heavier initial load. It should also be noted that these limitations are due in part to mindful compromises that were made to strengthen other aspects of the design. In particular, a key strength of this study is the implementation of a long term (20 week) training programme in a population of experienced resistance trained subjects.

CONCLUSIONS

This study suggests that starting with a lighter initial load results in the same improvements in strength as starting with a heavier initial

load when employing a progressive wave loading strategy. It may therefore be advantageous to start with a lighter initial load, as the same results can be achieved for the exertion of less effort. This result tends to support the commonly espoused training recommendation to “start light” if employing a progressive wave loading strategy, such that an athlete does not train harder than is necessary to achieve a given improvement in strength.

Conflict of interests: the authors declared no conflict of interests regarding the publication of this manuscript.

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